Coupled Thermal-Hydrological-Mechanical Analysis with TOUGH-FLAC

Jonny Rutqvist and Chin-Fu Tsang
Contact: Jonny Rutgvist, 510/486-5432, jrutqvist@lbl.gov

RESEARCH OBJECTIVES

The objective of this work is to develop a numerical simulator for coupled thermal-hydrological-mechanical (THM) analysis of complex geological media under multiphase flow conditions, with possible coupling to reactive transport modeling.

APPROACH

Two existing computer codes—TOUGH2 and FLAC-3D—were joined to develop a numerical simulator (named TOUGH-FLAC) for analysis of coupled THM processes in complex geological media under multiphase flow conditions. Both codes are well established and widely used in their respective fields. The TOUGH2 code is designed for geohydrological analysis of multiphase, multicomponent fluid flow and heat transport, whereas the FLAC-3D code is designed for rock and soil mechanics with thermomechanical and hydromechanical interactions. The two codes are executed on two separate meshes and joined with two coupling modules (Figure 1). A set of coupling modules can be exchanged with another set, depending on the type of rock and the studied problem.

ACCOMPLISHMENTS

A set of TOUGH-FLAC coupling modules has been developed for various applications. Recent applications of the TOUGH-FLAC simulator include:

- A study of caprock hydromechanical changes associated with CO_2 injection into a brine formation
- A study of the impact of coupled THM processes on the performance of the proposed nuclear waste repository at Yucca Mountain, Nevada, including drift-scale and mountain-scale coupled THM processes
- Coupled THM analysis of the Yucca Mountain Drift Scale Test
- Analysis of surface uplift during volcanic episodes
- A study of fault slip during underground injection CO_2 (ongoing)

SIGNIFICANCE OF FINDINGS

A coupled THM numerical simulator for multiphase flow conditions has been successfully constructed and its use demonstrated. The results from these simulations will be important for the performance assessments of geological disposal of CO_2 and spent nuclear fuel, and are also valuable in other applications (such as geothermal energy extraction and oil and gas reservoir engineering).

RELATED PUBLICATIONS

Rutqvist, J., Y.-S. Wu, C.-F. Tsang, and G. Bodvarsson, A modeling approach for analysis of coupled multi-phase fluid flow, heat transfer, and deformation in fractured porous rock. Int. J. Rock Mech. Min. Sci., 39, 429–442, 2002.

Rutqvist, J., and C.-F. Tsang, A study of caprock hydromechanical changes associated with CO_2 injection into a brine aquifer. Environmental Geology, 42, 296–305, 2002.

Rutqvist, J., and C.-F. Tsang, Analysis of thermal-hydrological-mechanical behavior near an emplacement drift at Yucca Mountain. J. Contaminant Hydrology, 62–63,1–16, 2003.

ACKNOWLEDGMENTS

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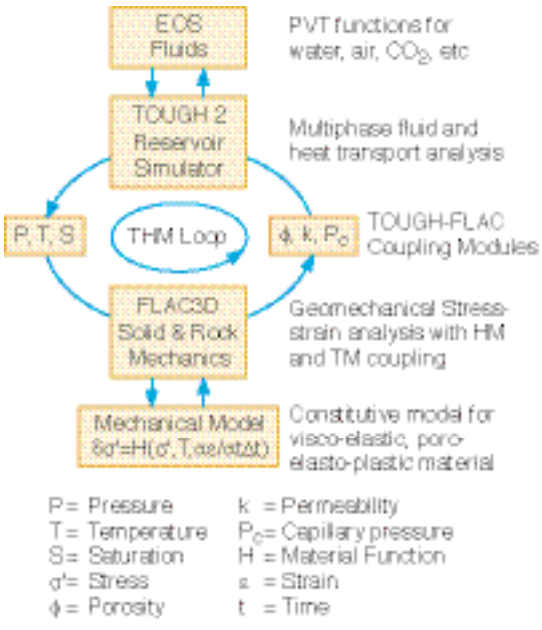

Figure 1. Schematic of linking TOUGH2 and FLAC3D for a coupled THM simulation